The $\phi(1020)$-meson production cross section measured with the ATLAS detector at $\sqrt{s}=7$ TeV

de Nooij, L.

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Appendix A

Relativistic Breit–Wigner signal shape

In this section the relativistic Breit–Wigner signal shape used for signal extraction is explained in more detail. The convolution of a Breit–Wigner p.d.f. with a Gaussian resolution function results in a p.d.f. that is often used to extract the $\phi(1020)$ yield.

In the analysis the signal shape is described as a relativistic Breit–Wigner form:

$$f_{\text{RelBW}}(m; m_0, \Gamma_0, J, R) = \frac{m^2}{(m^2 - m_0^2)^2 + m_0^2 \Gamma^2(m)}, \quad (A.1)$$

where the mass dependent width $\Gamma$ is defined as

$$\Gamma(m) = \Gamma_0 \frac{m_0}{m} \left( \frac{k(m)}{k(m_0)} \right)^{2J+1} \frac{F(Rk(m))}{F(Rk(m_0))} \quad (A.2)$$

$$k(m) = \frac{m^2}{2} \left( 1 - \frac{(m_a + m_b)^2}{m^2} \right)^{1/2} \left( 1 - \frac{(m_a - m_b)^2}{m^2} \right)^{1/2}, \quad (A.3)$$

with the function $F$ spin dependent Blatt–Weisskopf form factor [138],

$$F^{J=0}(x) = 1 \quad (A.4)$$

$$F^{J=1}(x) = \frac{1}{1 + x^2} \quad (A.5)$$

$$F^{J=2}(x) = \frac{1}{9 + 3x^2 + x^4} \quad (A.6)$$

The Blatt-Weisskopf form factors provide a better description of the shape of the resonance if the decaying particle has a non-zero spin. The interaction radius $R$ is in equation $[A.2]$ has an effect on the width of the resonance if the peak of the resonance is near-threshold and is zero for the $\phi(1020)$-meson [139]. This reduces the form factor to:

$$F^{J=1}(0) = 1, \quad (A.7)$$

so that also the fraction in equation $[A.2]$ is unity. The parameters $m_a$ and $m_b$ are the masses of the daughters of the decaying resonance, in this case $m_a = m_b = m_K$, the kaon mass. Using this
Figure A.1: The invariant mass distribution fitted with the non-relativistic Breit-Wigner (dashed line) and with the relativistic Breit–Wigner (solid line).

and that the spin $J = 1$, the mass dependent width reduces to:

$$\Gamma(m) = \Gamma_0 \left[ \frac{m^2 - 4m^2_K}{m^2_0 - 4m^2_K} \right]^{3/2}$$  \hspace{1cm} (A.8)

The difference between the non-relativistic Breit-Wigner in equation 6.1 and the relativistic Breit-Wigner in equation 1.5 is illustrated in figure A.1. The difference between the two line shapes is small, but the better description of the shoulder of the resonance at the high end by the relativistic Breit-Wigner is visible.